tions or concave portions on the surface of a substrate; and forming an optical thin film on the light diffusion control portion so as to have convex portions or concave portions having the same shape as that of the convex or concave portions of the light diffusion control portion. The optical thin film reflects light in a specific wavelength band and transmits at least visible light other than the light in the specific wavelength band.

[0016] By forming the light diffusion control portion having the plurality of convex or concave portions on the surface of the substrate and further forming the optical thin film so as to have convex or concave portions having the same shape as that of the convex or concave portions of the light diffusion control portion, light rays incident on the optical thin film have incident angles at the convex or concave portions of the optical thin film. Therefore, a predetermined percentage of the light in the specific wavelength band is diffuse-reflected at angles twice the incident angles from the optical thin film. Thus, the viewing angle of the screen is increased.

[0017] Also, since the convex or concave portions are provided on the surface of the substrate to form the light diffusion control portion, a projection screen having a simple structure can be achieved by forming the optical thin film so as to have the convex or concave portions having the same shape as that of the convex or concave portions of the light diffusion control portion. As a result, the variation of optical characteristics, viewing characteristics, and other characteristics can be reduced, and, accordingly, reliability is increased. Also, manufacturing cost can be reduced.

[0018] The light diffusion control portion may be designed according to an optical simulation so that the convex or concave portions determine the angle of the reflection from the optical thin film. Thus, the range of reflection angle can appropriately be set, and, consequently, viewing characteristics can be controlled. Thus, viewing characteristics can further be enhanced.

[0019] The light diffusion control portion may include a plurality of spherical beads having a predetermined diameter and a bead-fixing layer filling the spaces between the beads to fix the beads. The thickness of the bead-fixing layer may be set with respect to the diameter of the beads, thereby determining the angles of reflection from the optical thin film. By setting the angles of the reflection from the optical thin film depending on the thickness of the bead-fixing layer, the range of reflection angle can appropriately be set, and, consequently, viewing characteristics can be controlled. Thus, viewing characteristics can further be enhanced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] **FIG. 1** is a schematic illustration of a projection screen according to an embodiment of the present invention;

[0021] **FIG. 2** is a perspective view of the projection screen shown in **FIG. 1**;

[0022] **FIG. 3** is a schematic fragmentary enlarged view of the projection screen shown in **FIG. 1**;

[0023] **FIG. 4** is a schematic illustration of a projector using the projection screen shown in **FIG. 1**;

[0024] **FIG. 5** is a schematic lustration of a projection screen according to a modification of the embodiment;

[0025] **FIG. 6** is a perspective view of the projection screen according to the modification;

[0026] **FIG. 7** is a schematic fragmentary enlarged view of the projection screen according to the modification;

[0027] **FIG. 8** is a schematic lustration of a projection screen according to a modification of the embodiment;

[0028] **FIG. 9** is a schematic fragmentary enlarged view of the projection screen according to the modification; and

[0029] **FIG. 10** is a schematic lustration of a known projection screen;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Embodiments of the present invention will now be described with reference to the drawings.

[0031] **FIG. 1** shows a cross section of part of a projection screen **10** according to an embodiment of the present invention. **FIG. 2** is a perspective view of the projection screen **10**. **FIG. 3** is a fragmentary enlarged view of **FIG. 1**. **FIG. 2** does not show the parts above an optical thin film **12** for convenience. This projection screen **10** is a so-called reflective screen. The projection screen **10** includes a substrate **11**. The substrate **11** has a plurality of convex portions **11**A constituting a light diffusion control portion on the surface thereof. A predetermined percentage of the light reflected from the optical thin film **12** is diffused due to the presence of the convex portions **11**A. This mechanism will be described later. The optical thin film **12** serving as a band-pass filter is disposed on the substrate **11**. The optical thin film **12** has convex portions **12**A having the same shape as that of the convex portions **11**A of the substrate **11**. A protective film **13** covers the optical thin film **12**.

[0032] The surface of the substrate **11** has flat regions between the convex portions **11**A. Each convex portion **11**A may have a spherical surface having a curvature radius of several micrometers to several millimeters. The shape, curvature radius r, arrangement, area ratio, and surface properties of the convex portions **11**A are designed according to, for example, an optical simulation. The convex portions **11**A allow reflected light from the optical thin film **12** to diffuse at a predetermined percentage.

[0033] The substrate **11** is formed of, for example, a macromolecular material containing a black paint. Exemplary macromolecular materials include polycarbonate (PC), polyethylene terephthalate (PET), polyethylene naphthalate (PEN), polyether sulfone (PES), and polyolefin (PO). Since the substrate **11** is colored black with the black paint, it can serve as a light absorber for absorbing light transmitted through the optical thin film **12**, thereby increasing the black level on the screen to enhance the light/dark contract.

[0034] The optical thin film **12** is a dielectric laminate essentially composed of high-refractive-index layers **12**H formed of a dielectric material having a high refractive index and low-refractive-index layers **12**L formed of a dielectric material having a refractive index lower than that of the high-refractive-index layers **12**H that are alternately layered. Exemplary dielectric materials for the high-refractive-index layers **12**H include niobium pentoxide (Nb_2O_5), titanium dioxide (TiO_2), and tantalum pentoxide (Ta_2O_5). Exemplary